

WHAT IS CLAIMED IS:

1. An EGR-gas temperature estimation apparatus for an internal combustion engine which has an exhaust circulation pipe connected between an exhaust passage and an intake passage, an EGR control valve interposed in the exhaust circulation pipe and adapted to control flow rate of EGR gas flowing through the exhaust circulation pipe, and an EGR-gas cooling apparatus interposed in the exhaust circulation pipe, the EGR-gas temperature estimation apparatus comprising:

means for obtaining a temperature of the EGR gas on an inlet side of the EGR-gas cooling apparatus;

means for obtaining a corresponding value corresponding to the flow rate of the EGR gas flowing through the exhaust circulation pipe;

cooling efficiency obtaining means for obtaining a cooling efficiency of the EGR-gas cooling apparatus on the basis of the EGR-gas temperature on the inlet side of the EGR-gas cooling apparatus and the obtained corresponding value; and

outlet EGR-gas temperature estimating means for estimating a temperature of the EGR gas on an outlet side of the EGR-gas cooling apparatus, on the basis of the EGR-gas temperature on the inlet side of the EGR-gas cooling apparatus and the obtained cooling efficiency.

2. An EGR-gas temperature estimation apparatus for an internal combustion engine according to claim 1, further comprising coolant temperature obtaining means for obtaining a temperature of a coolant of the EGR-gas cooling apparatus, wherein the outlet EGR-gas temperature estimating means estimates the temperature of the EGR gas on an outlet

side of the EGR-gas cooling apparatus.

3. An EGR-gas temperature estimation apparatus for an internal combustion engine according to claim 2, wherein the outlet EGR-gas temperature estimating means estimates an EGR-gas temperature change by multiplying, by the cooling efficiency, the difference between the obtained temperature of the EGR gas on an inlet side of the EGR-gas cooling apparatus and the obtained coolant temperature, and estimates the temperature of the EGR gas on an outlet side of the EGR-gas cooling apparatus by subtracting the estimated EGR-gas temperature change from the temperature of the EGR gas on an inlet side of the EGR-gas cooling apparatus.

4. An EGR-gas temperature estimation apparatus for an internal combustion engine according to claim 1, wherein the cooling efficiency obtaining means obtains the cooling efficiency on the basis of a value obtained by dividing the obtained corresponding value by the obtained temperature of the EGR gas on an inlet side of the EGR-gas cooling apparatus.

5. An EGR-gas temperature estimation apparatus for an internal combustion engine according to claim 2, wherein the cooling efficiency obtaining means obtains the cooling efficiency on the basis of a value obtained by dividing the obtained corresponding value by the obtained temperature of the EGR gas on an inlet side of the EGR-gas cooling apparatus.

6. An EGR-gas temperature estimation apparatus for an internal combustion engine according to claim 3, wherein the cooling efficiency obtaining means obtains the cooling efficiency on the basis of a value obtained by dividing the obtained corresponding value by the obtained temperature of the EGR gas on an inlet side of the EGR-gas cooling apparatus.

7. An EGR-gas temperature estimation apparatus for an internal combustion engine which has an exhaust circulation pipe connected between an exhaust passage and an intake passage, an EGR control valve interposed in the exhaust circulation pipe and adapted to control flow rate of EGR gas flowing through the exhaust circulation pipe, and an EGR-gas cooling apparatus interposed in the exhaust circulation pipe to be located between the EGR control valve and a connection portion of the exhaust circulation pipe through which the exhaust circulation pipe is connected to the exhaust passage, the EGR-gas temperature estimation apparatus comprising:

inlet EGR-gas temperature obtaining means for obtaining, as an exhaust-circulation-pipe-inlet EGR-gas temperature, a temperature of the EGR gas at an EGR gas inlet, which is the connection portion of the exhaust circulation pipe through which the exhaust circulation pipe is connected to the exhaust passage;

EGR-gas-flow-rate corresponding value obtaining means for obtaining an EGR-gas-flow-rate corresponding value corresponding to the flow rate of the EGR gas flowing through the exhaust circulation pipe;

cooling efficiency obtaining means for obtaining a cooling efficiency of the EGR-gas cooling apparatus on the basis of the obtained exhaust-circulation-pipe-inlet EGR-gas temperature and the obtained EGR-gas-flow-rate corresponding value; and

outlet EGR-gas temperature estimating means for estimating, as an exhaust-circulation-pipe-outlet EGR-gas temperature, a temperature of the EGR gas at an EGR gas outlet, which is a connection portion of the exhaust circulation pipe through which the exhaust circulation pipe is connected to the intake passage, on the basis of the obtained exhaust-circulation-pipe-inlet EGR-gas temperature and the obtained cooling efficiency.

8. An EGR-gas temperature estimation apparatus for an internal combustion engine according to claim 7, further comprising coolant temperature obtaining means for obtaining a temperature of a coolant of the EGR-gas cooling apparatus, wherein the outlet EGR-gas temperature estimating means estimates the exhaust-circulation-pipe-outlet EGR-gas temperature on the basis of the obtained temperature of the coolant.

9. An EGR-gas temperature estimation apparatus for an internal combustion engine according to claim 8, wherein the outlet EGR-gas temperature estimating means estimates an EGR-gas temperature change by multiplying, by the cooling efficiency, the difference between the obtained exhaust-circulation-pipe-inlet EGR-gas temperature and the obtained coolant temperature, and estimates the exhaust-circulation-pipe-outlet EGR-gas temperature by subtracting the estimated EGR-gas temperature

change from the exhaust-circulation-pipe-inlet EGR-gas temperature.

10. An EGR-gas temperature estimation apparatus for an internal combustion engine according to claim 7, wherein the cooling efficiency obtaining means obtains the cooling efficiency on the basis of a value obtained by dividing the obtained EGR-gas-flow-rate corresponding value by the obtained exhaust-circulation-pipe-inlet EGR-gas temperature.

11. An EGR-gas temperature estimation apparatus for an internal combustion engine according to claim 8, wherein the cooling efficiency obtaining means obtains the cooling efficiency on the basis of a value obtained by dividing the obtained EGR-gas-flow-rate corresponding value by the obtained exhaust-circulation-pipe-inlet EGR-gas temperature.

12. An EGR-gas temperature estimation apparatus for an internal combustion engine according to claim 9, wherein the cooling efficiency obtaining means obtains the cooling efficiency on the basis of a value obtained by dividing the obtained EGR-gas-flow-rate corresponding value by the obtained exhaust-circulation-pipe-inlet EGR-gas temperature.